Consumer Surplus for Air Quality Improvement in the Transport Sector in Klang Valley, Malaysia: Contingent Valuation Method and Choice Experimental Approach

Masahina Sarabdeen[#1], Rafia Afroz*[2], A.C. Muhammadu Kijas*[3], Shanoo Sheikh [#4]

[1]Corresponding Author, Department of Economics, Collage of Business Administration
[4]Department of Clinical Psychology, Collage of Health and Rehabilitation
[#]Princess Norah Bint Abdurrahman University, Saudi Arabia
[2]Kulliyyah of Economics and Management Sciences
[*]International Islamic University Malaysia, Malaysia
[1]MSarabdeen@pnu.edu.sa/drsmasahina@gmail.com
[2]rafia@iium.edu.my
[3]Kulliyyah of Education
[4]Sheikhshanoo@gmail.com
[3]dracmkijas@gmail.com

Abstract-- **This study is an attempt to estimate consumer surplus for alternative air quality improvement in Klang Valley, Malaysia, using a double-bounded dichotomous choice contingent valuation method (CVM) and choice experiment (CE). Number of sick days, air pollution index, medical expenditure, outdoor activities, ethnic, city, age, and respiratory symptoms were found to be significant variables which affect the willingness to pay (WTP) of the respondents. Respondents' WTP is an average MYR 2.13 in CVM and the mean WTP for the new air quality management programme derived from CE is MYR1.99 per litre. The consumer surplus derived from CVM and CE is 0.23 and 0.09 respectively. Results show that although the consumer surplus derived from CVM is slightly higher than that from CE but they are not significantly different. The results suggest that both double-bounded CVM and CE can be successfully implemented for environmental valuation in Klang Valley.**

Keywords: Consumer Surplus, Double-bounded Dichotomous Choice Contingent Valuation Method, Choice Experiment, Willingness to Pay, Air Quality

1. Introduction

The past 10 to 15 years has recorded a noteworthy boost in research on the effects of air pollution on public health in developing and developed countries. According the United Nations Environment Programme, 1.1 million people are breathing unhealthy air. Exposure to urban air pollution caused almost two-thirds of an estimated 800,000 deaths [1]. There is a growing concern of respiratory diseases and poor academic performance due to air pollution [2], [3], [4], [5], [6], [7]. Air pollution may be defined as the contamination of outdoor or indoor air by a natural or man-made agent in such a way that the air becomes less acceptable for intended uses [8], [9]. An air pollutant is defined as any substance present in or released to the atmosphere that adversely affects human health or the environment. There are thousands of pollutants present in the atmosphere but six are of special concern because they are emitted in large quantities. They are carbon monoxide, sulphur dioxide, nitrogen dioxide, hydrocarbon and particulate matter. Among these six pollutants, carbon monoxide (CO) is the most important anthropogenic Green House Gas which has the largest contribution from human activities.

For the past 15 years, the land transport dominates the total air pollution in Malaysia. It contributes more than 70% of the total air pollution [10]. According to the Department of Environment (DOE), the four main local sources of air pollution in 2016 were vehicular emissions, power plants, industrial processes, and open burning at solid waste dumpsites [11]. The total number of registered vehicles has been continuously increasing from 8,550,469 in 1997 to 24,159,820 in 2014 [10].

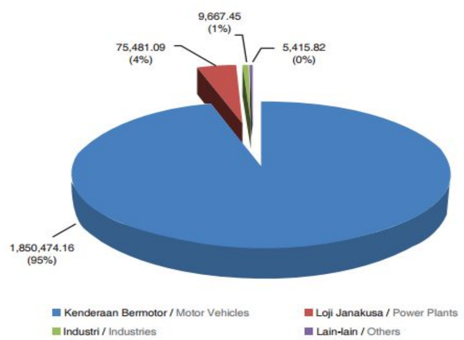


Figure 1. Source: CO Emission by Sources (Metric Tons), 2014 (DOE, 2015)

According to DOE (2015), it was estimated that in 2014 the CO air pollutant emission load accumulated to 1,941,039 metric tonnes, in which 95% of CO emissions was contributed by the transport sector as shown in Figure 1. Other pollutants load from the transport sector was estimated in the same year as 836,708 metric tonnes of nitrogen oxides (NO2); 221,471 metric tonnes of sulphur dioxide (SO2) and 25,673 metric tonnes of particulate matter (PM) as shown in Figure 2.

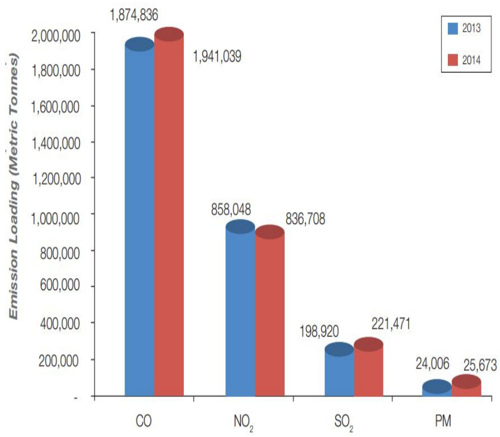


Figure 2. Source: Air Pollutant Emission Load from All Sources, 2013-2014 (DOE, 2015)

It shows comparison of the combined air pollutant emission load from the all the sources in 2013 and 2014, and it illustrates that CO is the major air pollutant among other six pollutants emission levels due to transport sector [10].

The Klang Valley region is the heart of economic growth in Malaysia. The region comprises the city of Kuala Lumpur and nine other municipalities – Ampang Jaya, Kajang, Klang, Petaling Jaya, Putrajaya, Selayang, Sepang, Shah Alam, and Subang Jaya. The population of this region is around 8 million people, and approximately 40% of the nation's GDP is connected to this area. Malaysia is presently in the phase of fluctuating from a developing market to a developed market, and in pursue of growth. Shah Alam, Petaling Jaya, and Batu Muda were selected from Klang Valley (Figure 3).

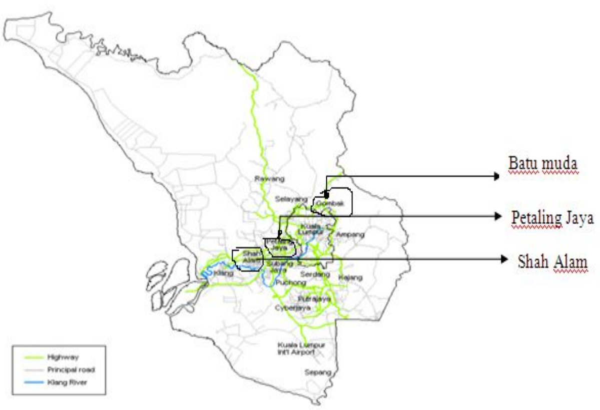


Figure 3 Map of Klang Valley

The reasons for selecting the above-mentioned urban areas were that these areas had economic growth of 11.2% per annum which were considered as fast and were recognised as unhealthy air quality regions by the DOE [11]. The number of unhealthy days experienced by Klang Valley was 93 days in 2001 and it increased to 185 days in 2002, which was more than double compare to previous year. Then again, it increased greatly to 251 days in 2014 [10]. The report of the DOE Malaysia reveals that Klang Valley was the most prone region to serious air pollution compared to other parts of the country [11]. With mountains in the east and the Straits of Malacca to the west, and being highly developed and densely populated, the Klang Valley provided a conducive environment for pollutants to accumulate particularly when atmospheric conditions are stable.

The focus of the study is, therefore, the households in Klang Valley, many of whom have been suffering from respiratory diseases caused by air pollution. Given the importance of improved air quality in people's lives, it is high time that every citizen in this country should realise the need to maintain the air quality, and as such, they have the responsibility to help in these efforts. The government alone could not do it because of budgetary problems, aside from the traditionally low priority given to the transport sector. All stakeholders should realise that the key to the sustainable environment was effective air quality management. Unfortunately, there was no study on the issue of WTP to improve the local air quality using CVM and CE. Hence the research will fill the gap in this area and come up with an estimation of the WTP to help produce multiple policies and recommendations.

The paper designs a theoretical framework of CVM and CE to estimate the WTP of the respondents to improve the air quality in Klang Valley. It then compares the WTP obtained from CVM and CE. CVM and CE is based on constructing a hypothetical scenario, so that it would help to investigate how people react to the changes in air quality and how much they may want to pay for that. In this way, air quality, which is an intangible good but does not have a market price, can have a potential monetary value [12]. It concludes with appropriate recommendations.

2. Literature Review

In Malaysia, air pollution has been documented as one of the major possible concerns of adverse health effects [13], [14], [15], [16], [17]. Air quality can be defined as the concentration of air which is not harmful to human health and the environment. Air pollution index (API) is recognized as simple and generalized way to describe the air quality in Malaysia [10]. API is a quantitative measure that describes the ambient air quality. The purpose of the Air Quality Index standard is to recognize the individual pollutants and concentrations at which they become harmful to the human health and the environment. The seven main pollutants; TSP, PM_{10}, NO_2, SO2, CO, O_3 and lead, are used in the computation of API in Malaysia.

According to the air pollutant components, air quality is good when API is between 0 and 50; it is moderate when API is between 51 and 100. If API is between 101 and 200, air quality is unhealthy and if API is between 201 and 300, air quality is very unhealthy. The API between 301 and 500 means air quality is hazardous. If the API exceeds 500, a state of emergency is declared in the reporting area [10].

Most of the existing studies have given emphasis to haze and their health effects in Malaysia [18], [17], [16], [15], [19], [14], [20], [21], [22], [23]. Few studies estimated the human health effects in Malaysia from a widespread series of forest fire (haze) with the finding that haze episodes badly affect the human health in Malaysia [18], [23]. Zailina *et al*. tried to estimate the impacts of haze episodes on Asthmatic children in Kuala Lumpur [17]. A similar study has been carried out by Juliana to know the link between air pollution and its effects on children health in two different areas; Kuala Lumpur (heavily air polluted area) and Terengganu (low air polluted area)[16]. Some studies concluded the same finding that air pollution significantly affects children's health especially the children with asthma [17], [16].

Another study conducted by Jamal *et al*. found the links between mean daily concentrations criteria of air pollutants and the risks of respiratory cardiovascular morbidity and mortality at hospitals in the Klang Valley from January 2000 to December 2003[14]. Their interesting findings indicated that the significance of relative risk was not only linked with high level of air pollutants such as PM10 and CO but also with very low level air pollutants such as SOx, NO2 which were below the national air quality guidance. Thus, it seems to be a challenge for the government to upgrade the national air quality guidance.

Mazrura *et al*. have assessed the first daily air pollution time series study to recognize the trend of the air pollutants and their link with the mortality rate in Klang Valley, Malaysia from 2000 to 2006 using a protocol developed by Public Health and Air Pollution in Asia-Science Access on the Net (PAPA-SAN) [20]. A conclusion from the study reveals that ozone and PM10 have the link between mortality risks and air pollutants. This finding is similar to other study related with mortality risks and air pollutants [24].

The growing dependence on private modes of transport in Klang Valley is one of the major contributing factor in air pollution in Malaysia. The private cars and motorbikes, in Klang Valley, are emitting more air pollutants among other vehicle types. It was noticed that the share of private vehicles increased from 66% in 1985, 92% in 2009, to 99.3% in 2014 while the share of public transport had been continuously declining from 34% in 1985 to 20% in 1997, 8% in 2009 and 0.7% in 2014 [10]. Since the transport sector in Malaysia is heavily reliant on petroleum, it contributes significantly to the greenhouse gas emission and thus creates environmental and health problems. Air pollution related diseases were among the highest ranked diseases suffered by Malaysian citizens with the elderly and children being the most vulnerable [23], [25], [14]. The current trend of inter-modal (private and public) transportation in Malaysian cities was not a desirable trend from the perspective of energy, environment and public health. Large numbers of vehicles on the road have caused severe congestion in almost all parts of the highway network and corridors, especially in the central business areas and inevitably the environment in these areas has deteriorated due to motor vehicles emissions. Unfortunately, there is dearth of serious research on this area. This study was a positive step in the country's transport sector since this study used the fuel price as the payment vehicle for improving the air quality. Because of its budgetary constraints, the government could no longer afford to subsidise the fuel price. Nor should it allow vehicle users to continue thinking that fuel was cheap. The price of fuel should reflect the opportunity costs of competing uses, as well as the environmental cost of oil extraction and consumption. The results of the study would provide valuable information to policymakers to fully realise the value of improved air quality in Klang Valley. This information could inform policies that will institutionalise fuel pricing and plough back the revenues generated by the transport sector that would produce the sustainable transportation system in Klang Valley.

As regards to the research methods, the CE is becoming a popular method due to its remarkable advantages such as increasing attribute variation, data collection efficiency, and investigation of non-existing alternatives or options. CE has been used by many researchers to estimate non-market values for various environmental and recreational servicers of ecological goods [26], [27], [28], [29], [30] waste management [31] environmental policy assessment [31], [32], [30] tourism study [34] and health care researches [34], [35], [36]. Many researchers have also used choice modeling for transportation analysis [37], [38], [39].

The existing literature reveals that the following studies have used CVM and CE to estimate the WTP [40], [31], [32], [41], [42], [43], [44], [47], [48], [47], [48], [49].

He *et al*. measured WTP for wetland preservation and restoration using both CVM and CE in Canada [40]. Hynes *et al.* utilised CVM and CE to assess the public's willingness to pay for the Agri -Environmental Policy [31]. Christie & Azevedo conducted validity tests using CV and CE for improved water quality at Clear Lake, USA [32]. Scarpa and Willis elicited individual's WTP for traffic-calming scheme [42]. Mogas *et al*. used CVM and CE in their study to assess convergent validity for identical afforestation programs in Canada [41]. Jina *et al*. estimated residents' WTP for alternative solid waste management policy changes in Macao using CE and CVM (double bounded) question format [50]. They used monthly garbage fee as a payment vehicle. Colombo *et al*. investigated WTP to mitigate the off-site impacts of soil erosion for a watershed in Andalusia, Spain [44]. Authors Foster and Mourato estimated the social value of the services, provided by the charitable sector in the United Kingdom [48]. Christie and Azevedo investigated the WTP of respondents in preserving and improving the lake's water quality in north-central Iowa [32]. Furthermore, Boxall *et al*. measured the environmental quality changes due to forest management practice on recreation on moose hunting [49]. Adamowicz *et al.* also drawn out the responses that permit the estimation of preferences over attributes preserving the old-growth forest [45]. Hanley et al. conducted two studies to estimate the WTP of the respondents [46], [47]. One was for the conservation of environmentally sensitive areas and another one was for alternative forest landscapes.

To date, few studies had been carried out to estimate the willingness to pay (WTP) to improve the local air quality [51], [25], [52]. Furthermore, the existing studies in Malaysia relied solely on CVM estimation. It was not preferable to depend on a certain method due to their unique merits and demerits. Diamond and Hausman stated that many studies which employed the CVM were facing problems due to the inadequate scenario design and sampling technique of CVM [53]. Another problem of this approach was its dependence on the precision of the information and wrong information which was discovered after the fact could not be changed.

The CE approach, on the other hand, depends on the presentation of a choice situation using an array of attributes. Thus, it depends less on the precision and unity of any fussy description of the good or service. Moreover, it depends more on the accuracy and completeness of the characteristic and facial appearance used to describe the situation. Therefore, respondents were asked for their preferred alternative from a 'choice set' made up of a set of different packages. Thus, the choice replicated the trade-offs that each chose between the attributes of the situation. For the researcher, it was possible to estimate the economic values or the respondent's WTP associated with other attributes, when price or cost factors were included as an attribute in a package. The current research differs from earlier studies conducted in Malaysia [51], [25], [52] in the sense that the previous studies used CVM only. Although CE was not a new concept, its application in Malaysia is limited. The CE was the popular and recommended method [49], [45], [48] used by other researchers in developed countries. The current study tries to estimate the WTP of the respondents using both CVM and CE. By doing this, the study attempts to determine whether there are any significance differences between the results obtained from both methods.

3. Theoretical Framework and Methodology

3.1. Theoretical Framework

The theoretical framework of CE has been developed based on the theory of [54], [55], [56], [57]. According to them, the utility function of an individual is decided by good consumed (X), leisure time (L), individual's characteristics (Z), and the individual's health status (S). In this model, an individual's health status refers to the number of sick days (NSD) due to respiratory symptoms (RS) which are assumed to be due to air pollution. It is simplified as;

$$U = U(X, L, Z, S) \qquad (1)$$

The health status or NSD of an individual depends on certain biological factors, environmental quality, medical expenditures (ME), and socio-economic factors. This model considers the biological factors as constant. Environmental quality refers to the air pollution index (API) in Klang Valley which depends on the concentration of different air pollutants. In Klang Valley, API is above the standard level and is regarded as affecting the environmental quality and indirectly affecting the health status of the individuals. The ME is also an important factor in determining an individual's health status:

$$S = S(Q, M, Z) \qquad (2)$$

Where Q is the API, M is ME, and Z is the socio-economic factors. Here, ME refers to the individual's cost for medicines, hospitalisation, pathological tests, doctor's consultation, travel to doctor's clinic, and health insurance cost. Socio-economic factors such as individual's household income (HIC), age (AGE), gender (GEN), the number of dependent members and city (CITY), and environmental variables such as RS, outdoor activities (OA), and environmental consciousness (EC) were included in the model. The expenditure function for an individual can be written as:

$$e = (p_x, w, p_m, Q, M, Z- \bar{U}) = \{\min p_x x + p_m M - (Y_{NW} + w(T - L - S(Q, M, Z))\} \text{ Subject to } U(X, L, Z, S) \geq \bar{U} \qquad (3)$$

Where, P_x is the price of good x consumed, w refers to the wage rate, P_m shows the ME, Y_{NW} is non-wage income, T is total time available, L is the leisure time, and U represents the average utility of the respondents. For convenience, the expenditure function omits the Y_{NW}, non-wage income, and T total time available.

In Malaysia, if the government introduces transportation policies to improve the air quality in Klang Valley, the API will reduce to standard levels from which it can be assumed that as a result, air quality improvement can increase the individual's indirect utility levels by reducing the NSD, ME, and increasing leisure time.

In this study, consumer surplus (CS) was estimated based on the compensation variation measure. Here, CS measures the change in expenditure that would make an individual indifferent between the initial and subsequent situations after the transportation policy is implemented by the government assuming the individual has the right to maintain the initial utility level. Based on the indirect utility functions, the compensating surplus could be illustrated as follows:

$$CS = e\ (p_x,\ w, p_m, Q^0,\ M^0,\ Z - \overline{U}\ ) - e\ (p_x,\ w, p_m, Q^1, M^1, Z - \overline{U}\ ) \quad (4)$$

According to Equation (4), the consumer surplus should differ with API, ME, socio-economic characteristics, and average utility of the respondents. From the theory, the consumer surplus indicates the WTP of the individual. Hence, in the equation, CS refers to the WTP of the respondents for improving air quality in Klang Valley, Malaysia. Hanemann stated, if the researcher assumes that the utility function has unobservable component, they are treated as stochastic [59]. The most common approach is to assume that unobservable component (ε) is independently and identically distributed random variables with an expected value of zero [59], [41].

Then, the respondent's utility function becomes Random Utility Theory as follows:

$$U_{ij} = V_{ij}\ (X, L, Z, S) + \varepsilon_{ij} \quad (5)$$

3.2. Selection of Attributes and their Levels of CVM and CE

Environmental goods and services are not tradable in any markets as they are not man-made products, people cannot value these goods in monetary terms. Stated preference (CVM and CE) techniques are the only way to estimate non-use value of environmental resources. Questionnaire is a crucial tool for estimating an accurate value of an individual for the non-market goods services. Since the air quality is an intangible good, this research is highly dependent upon the survey method. Survey is the most commonly used method in CVM and CE [60]. The same strategy is employed in this current study.

Survey instruments were selected from literature review, focus group discussion (FGD) and pilot study. Most of them were initially taken from existing literature [56], [57], [61], [62], [63], [64], [65], [66, [67]. This was helpful to establish the appropriate choice set formats and the levels of attributes for each choice set. The attributes and their levels used in this study are presented in Table 1.

Table 1 Attributes and Levels

Attributes	Levels
Sick days (SD)	5 days per month 4 days per month 3 days per month
Medical Expenditure (ME)	50 RM[a] 40 RM 30 RM
Air pollution Index (API)	Unhealthy Air Day Moderate Air Day Good Air Day
Bid	1.90 RM per litter 2.0 RM per litter 2.10 RM per litter

[a](1 USD = MYR 3.19)

In this study, primary and final FGD were conducted. The primary FGD were selected from professors and researchers specialising in air pollution related studies. The final FGD was selected from lower, middle, and higher income households with each group comprising three members. A pilot study was conducted among 30 respondents in Klang Valley for CVM in June, 2014. Fuel price was used as a payment vehicle for the government to get extra income to improve air quality by upgrading the transport sector.

3.3. Choice Experimental Design of CVM and CE

In CE, an orthogonal experimental design was used to develop the combination of attribute levels for the choice sets using SPSS-20. Sixteen options of various combinations of the attributes and their levels and 16 options were blocked into four choice sets in each questionnaire. Each choice set had two improved options plus a base option. The respondents were given four choice sets and asked to state their preferences for the current situation or the new improved options for improving the air quality in Malaysia. Figure 4 illustrates an example of a choice set.

In this study, prior to presenting the CVM dichotomous choice question to the respondents, they were informed about the current air quality in Klang Valley including its API, the health impact of air pollution and its implication on the environment, and the policies to improve the air quality in Klang Valley using the show cards. The improved air quality management plans were then presented. The respondents were told clearly that if they chose the improved plan, they would have to pay the extra payment for fuel price (RM/litre) (BID) directly to the government from their pockets for a certain period.

CHOICE SET OF AIR QUALITY IMPROVEMENT

In this section you will examine 2 different scenarios that offer you the choice of improving the air quality in Klang Valley. Which option would you select? Keep in mind your income, monthly expenditure and your family's pain, discomfort, and medical expenditure due to air pollution every month. We want you to indicate for each scenario which option you would choose, if either.

Q2. Consider the following two options as the ONLY once available as in SHOW CARD to improve the air quality in Klang Valley. Which option would you select? Keep in mind thecondition you would want and your income.

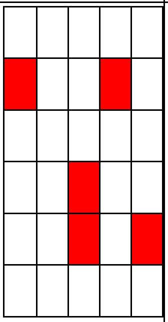
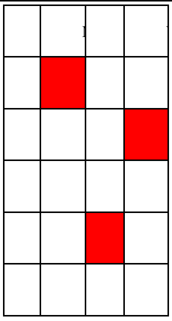
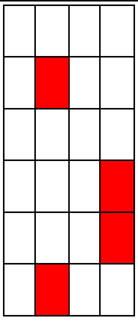
Attributes	Current air quality condition	Alternative air quality improvement plan	
		Option 1	Option 2
Sick Days 	 5 Days of Sickness	 3 Days of Sickness	 4 Days of Sickness
Medical expenditure 	 RM 50	 RM 30	 RM 30
Air Pollution Index (API) 	 Unhealthy Air	 Moderate Air	 Good Air
Cost per litter of petrol	RM 1.90 ☐	RM 2.00 ☐	RM 2.10 ☐

Figure 4 Showcard for CE

Respondents who chose the improved plan were further asked to reveal their monthly WTP (dichotomous choice format) to improve air quality. Respondents who chose the current management plan were not given any WTP question (Figure 5).

3.4. Sample Size and Data Collection

The total number of sample size 600 is decided after considering the available evident [68], [69], [70]. Louviere et al. mentioned the minimum 50 respondents should be selected for each sub-sample [68]. Hensher et al. (p. 194) mentioned that "…minimum sample sizes of 50 decision makers choosing each alternative" [69]. Meanwhile, Hair stated that a variable can take 10-20 respondents [70].

THE VALUE OF AIR QUALITY IMPROVEMENT

<u>This section presents how you value air quality improvement in Klang Valley, Malaysia.</u>

Transport is the prominent source of air pollution in Klang Valley, Malaysia. People tend to own vehicles due to inadequate public transportation to meet the demand of Klang Valley citizens. Also many vehicles on the road are contributing to high air pollution by burning of fossil fuel. Currently, the citizens in Klang valley are experiencing 5 sick days per month, spending RM 50 for medical expenditure per month and the API indicates the unhealthy days in half of the month (Department of Environment, 2011). Now, you are paying the fuel price of RM 1.90 per liter. If the government wants to improve the air quality in Klang valley, the government needs to invest large amount of capital to improve and upgrade the current public transportation in order to reduce private vehicles on the road. The money for implementing the management policies should come from the citizens of Klang Valley through the extra payment for fuel price (RM/liter). The government is planning to improve the air quality in Klang Valley. Now you are asked to vote for the improved options

Q6. Are you willing to vote for option 2 for improving the air quality in Klang Valley?

Yes	1	(go to question Q7)
No	0	(go to question Q10)

Q7. Are you willing to pay extra 5 cents per liter of petrol for the cost so that the government can achieve this program to improve the air quality in Klang Valley?

Yes	1	(go to question Q8)
No	0	(go to question Q9)

Q8. Are you willing to pay extra 10 cents per liter of petrol for the cost so that the government can achieve this program to improve the air quality in Klang Valley?

Yes	1	(go to question Q10)
No	0	(go to question Q9)

Q9. Are you willing to pay extra 3 cents per liter of petrol for the cost so that the government can achieve this program to improve the air quality in Klang Valley?

Yes	1	(go to question Q10)
No	0	(go to question Q10)

Q10. How much the most you are willing to pay for the cost so that the government can achieve this program to improve the air quality in Klang Valley? Please specify…RM…………

Figure 5. The Iinstrument Used to Gather CVM Estimates of the Air Quality Improvement

Thus, after considering the total number of variables used in the current study which are fourteen and times maximum amount of respondents by twenty becomes two hundred and eighty respondents. Thus, the number of respondents increased to 300 for each CVM and CE. For the CVM, a sample of 300 respondents was divided into three groups and was given different amounts of initial BID as stated in Figure 5.

Cluster sampling technique was used. Klang Valley has six urban areas, namely Shah Alam, Petaling Jaya, Batu Muda, Kuala Lumpur, Klang and Kajang. From these six urban areas, three urban areas such as Shah Alam, Petaling Jaya, and Batu Muda were selected. They are considered as highly, medium and low polluted areas, respectively, within Klang Valley. Four sections are selected randomly from the three urban areas. From each section 50 respondents were selected.

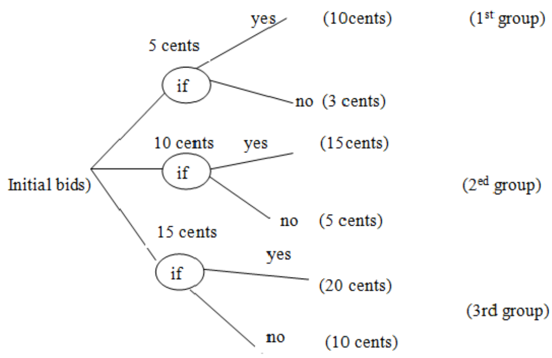


Figure 6 The BID design for double-bounded dichotomous choice for CVM

3.5. Model specification for CVM and CE

3.5.1 Logit Model for CVM

For the CVM, the binary logit model is chosen to estimate the WTP of the respondents. The dependent variable is WTP for air quality improvement in Klang Valley. Since the dependent variable is a dummy variable, if the respondents are willing to pay for air quality improvement, it takes 1, otherwise it takes the value of 0 [71]. The model is as follows:

$$LogP_i/(1-P_i) = Z_i = \beta_0 + \beta_i X_i + e \quad (6)$$

Where,

P_i = 1 if the respondent is willing to pay for improved air quality

P_i = 0 for otherwise

X_i = Independent variables

β_0 = Constant term

β_i = Coefficient of independent variables

e = The error or disturbance term, i = 1,2,3,…..n.

Mean WTP will be calculated by assuming no negative values for air quality improvement in Klang Valley and using the formula suggested by Hanemann [58]:

$$E(WTP) = \left(\frac{1}{\beta_1}\right)^* \ln\left(1+\exp^{\beta_0}\right) \quad (7)$$

3.5.2 Conditional Logit Model for CE

In CE, a conditional logit model was used in this study. If a specification contains the attributes and the individual characteristics as regresses, it is classified as a conditional logit model [72] as stated in equation (8). The dependent variable was the utility of the respondents associated with the air quality options. Random Utility Theory suggests that the individual chooses between groups of choice set on the basis to maximise their individual utility. The utility level depends on a particular choice and is a combination of the weighted attributes based on their relative importance. The individual's indirect utility function can take different models. The easiest model is the linear model as in equation (8)

$$V_{ij} = ASC + \sum \beta_k X_k, \text{ where i =i……k} \quad (8)$$

Where, V_{ij} is utility associated with the air quality option, β is a vector of marginal utility parameters, and X is a vector of attributes (k) from a choice set. ASC is alternative specific constant. Implicit price (marginal rate of substitution) for each attribute and the trade-off among those attributes and the consumer surplus (CS) was estimated using the best model estimators obtained from the conditional logit models [50], [47]. The formula for the implicit price is as follows:

$$\text{Implicit price} = -\frac{\beta_k}{\beta_c} \quad (9)$$

Where, β_k stands for the coefficient of the attributes in question and β_c stands for the coefficient of the monetary attributes [74]. Using the results from the conditional logit, the CS can be estimated by employing the following equation [49], [74]:

$$WTP = -\frac{1}{\beta_m}(V^0 - V^1) \quad (10)$$

Where β_M is the coefficient of the monetary attribute and is known as the marginal utility of income, and $V_{0,}$ and V_1 represent current and improved states, respectively.

4. Results and Discussion

4.1. Socio-economic Characteristics of the Respondents

Table 2 summarises the descriptive statistics of the socio-economic characteristics of the respondents. The selected sample was representative of Malaysia's total population. The sex distribution in the sample is 34.2% male and 65.8% female. In this survey, 46.3% of respondents were aged between 20-30 years, 30.7% were 31-40 years, 15.5% were 41-50 years, and 5.5% were 51-60 years. The majority of the respondents were Malay (81%), 14.3% were Chinese, and 4.7% were Indian that represents the Malaysian demographical distribution.

The average total number of family members of the respondents is four and ranged from three to six total family members. Total number of dependents of the respondents, 63.4% had one-three dependents, 16.6% had four-six dependents, 2.3% had seven and above dependents, and 17.7% had no dependents. As for educational attainment, the majority of the respondents have a diploma and above (60.9%). The highest income level of the respondents (41.8%) was reported between RM 3001-RM 6000, 37.8% earned between RM 1001-RM 3000, 7.7% earned between RM 6001-RM 9000, 7.5% of earned RM 9001 and above, and 5.2% had the least income level of RM 1000 and below.

The respondents were asked whether they experienced any respiratory symptoms such as fever, sneezing, coughing, asthma, runny nose, chest discomfort, sore throat, and eye irritation during the last three months. The majority of the respondents (83.5%) reported that they or a family member staying with him/her experienced respiratory symptoms, 16.5% of the respondents did not experience respiratory symptoms.

Table 2 Profile of the Respondents

Characteristics	Item	Frequency	Percentage
Gender	Male Female	205 395	34.2% 65.8%
Age	20-30 years 31-40 years 41-50 years 51-60 years	278 184 93 45	46.3% 30.7% 15.5% 7.5%
Ethnicity	Malay Chinese Indian	486 86 28	81.0% 14.3% 4.7%
Number of Family Members	1-3 members 4-6 members 7 and above	216 280 104	36.0% 46.7% 17.3%
Total number of Dependent	Below 0 1-3 members 4-6 members 7 and above	106 380 100 14	17.7% 63.4% 16.6% 2.3%
Educational Level	Never gone to Schoo Primary School SRP/PMR SPM/SPVM STPM Diploma Bachelor Post graduate	6 12 27 150 39 137 194 35	1.0% 2.0% 4.5% 25.0% 6.5% 22.8% 32.3% 5.8%
Household monthly Income	Below RM1000 RM 1001-RM 3000 RM 3001-RM 6000 RM 6001-RM 9000 RM 9001- and above	31 227 251 46 45	5.2% 37.8% 41.8% 7.7% 7.5%

4.2. Estimation Results from Double-Bounded Method DC from CVM

In the CVM analysis, three logit models were employed. Three models were used to check whether there are differences between the dependent and independent variables and to determine the fitness of the models in this study. In model 1, only the socio-economic variables were included. In model 2, the environmental variables were included with the socio-economic variables. In model 3, health variables were included with the socio-economic and environmental variables. All the independent variables used in these three models are discussed in Table 3.

Most of the socio-economic variables; age, ethnicity, income, and level of education are statistically significant in model 1. The negative coefficient for age is significant at 1% level. This indicates that, holding all other variables constant, younger people are willing to pay more (4% relatively) than older people. The result suggests that the younger generation makes more mature decisions about health and environmental issues while older people are more resistant to new ideas and do not want to change their beliefs and lifestyle. For this reason, they are willing to pay less. This result is consistent with the study conducted by Wang et al. on the relationship between poor air quality and residents' WTP for improved air quality in China [30]. Some other studies; [75], [76], [40] also discovered that age had negative relationship with the WTP.

Table 3 Parametric Estimates for Logit Model

Variables	Model 1 Coefficient S.E	Model 2 Coefficient S.E	Model 3 Coefficient	S.E
CITY	0.276 0.276	3.293 2.217	3.594	1.755
GEN	-0.177 -0.255	-0.176 0.265	0.019	0.205
ETH	-0.766 0.313	-0.540 0.364	-0.508	0.289
AGE	-0.039 0.013	-0.036 0.014	-0.025	0.110
DEP	0.094 0.075	0.069 0.077	0.042	0.056
HIC	0.442 0.221	0.765 0.657	0.403	0.542
EDU	0.064 0.028	0.008 0.298	0.003	0.223
ENV		-0.268 0.621	0.551	0.493
OA		0.062 0.024	0.044	0.014
API		0.078 0.050	0.086	0.040
RS			0.917	0.250
NSD			0.030	0.024
ME			0.004	0.001
Summary Pseudo-R^2	**0.04**	**0.07**	**0.10**	

Note: CITY = city, Age = Age, ETH =Ethnicity, GEN = gender, DEP = number of dependents, HIC = Household income, EDU = Education, OA = Outdoor Activities, NSD = number of Sick Days, API = Air Pollution Index, BID = Extra payment for fuel price (RM/liter), RS = Respiratory Symptoms, ME = Medical Expenditure

The coefficient of ethnicity is also negative and significant at 1% level of significance. This result indicates that non-Malays are willing to pay more than Malays for air quality improvement in Klang Valley, Malaysia. The odds of WTP decreases by 53% for the Malays relative to non-Malays. This result is inconsistent with the study of Jamal to non-Malays. This result is inconsistent with the study of Jamal which found that Malays are more willing to pay than non-Malays for waste management in Malaysia [14].

As expected, the coefficient of education is positive and significant at the 5% level. The coefficient of income is also positive and significant at the 1% level. The odds of WTP for highly educated people increases by 6% than the less educated holding all other variables constant. The WTP literature commonly supports the positive results of these two variables. For instance, the level of income and educational level have a positive effect on WTP in several studies [31], [40], [50], [77], [78], [79].

In model 2, only outdoor activities among the environmental variables are positive and significant at the 5% level. The positive coefficient for outdoor activities indicates that holding all other variables constant, people involved in more outdoor activities are more willing to pay than those who are less involved in outdoor activities. The odds of WTP increases by 6% for the respondents who spend more time for outdoor activity than the respondents who spend less time on an outdoor activity, other things remaining constant. As expected, outdoor activities have a positive relationship with the WTP of the respondents. This finding suggests that people who do more outdoor activities prefer air quality improvement which leads them to express a higher WTP value. This finding contrasts with Amalia who found that people involved in more outdoor activities were willing to pay less for the air quality improvement in Jakarta [81].

In model 3, only age (p = 0.05), city (p = 0.05) and ethnicity (p = 0.05) among the socio-economic variables, the environmental variables such as air pollution index (p = 0.05) and outdoor activities (p = 0.01), and health variables such as respiratory symptoms (p = 0.01) and medical expenditures (p = 0.01), positively and significantly affect the WTP of the respondents. The positive coefficient of city indicates that holding all other variables constant, people from a polluted city are willing to pay more than people from less a polluted city. It was expected that people residing in highly polluted areas are willing to pay more than those residing in less polluted areas. This result seems reasonable since people residing in highly polluted cities experience more health problems and unhealthy air. This can be associated to a better understanding of the problem and WTP for air quality improvement in their city.

Also, the positive coefficient of air pollution index indicates that ceteris paribus, the respondents are willing to pay more as a result of experiencing a higher number of unhealthy days and vice versa. The odds of WTP increases by 8% for the respondents who experienced a higher number of unhealthy days relative to the respondents who experienced a lower number of unhealthy days, ceteris paribus. In other words, if the air pollution index is high, people are willing to pay more than when the air pollution index is low because a high air pollution index indicates a greater number of unhealthy days. If people find the air is unhealthy, they are willing to pay more to improve the air quality in Klang Valley. This result is consistent with other studies [82], [81].

As expected, the positive coefficients of respiratory symptoms (p = 0.001) and medical expenditure (p = 0.001) indicate that, ceteris paribus, respondents with more respiratory symptoms and have higher medical expenditure are more willing to pay than respondents with less respiratory symptoms and lower medical expenditures. This result seems realistic since a higher level of respiratory symptoms, and more medical expenditure could be associated with a better understanding of the problem and more ability to pay. The positive relationship between these two variables is supported by the WTP literature [81], [83], [56].

The McFadden –R^2 values for their models are 0.04, 0.07, and 0.10 for model 1, model 2, and model 3, respectively as shown in Table 3. These values indicate goodness of fit and show that the models are suitable for predicting WTP values of the respondents to improve the air quality in Klang Valley.

4.3. Estimation Results from CE

In the CE analysis, simple conditional logit model (SCLM) and conditional logit interaction model (CLIM) were employed. Since this CE involves generic instead of labelled options, the alternative specific constant (ASC) is equal to 1 when either option 1 or 2 is chosen and equal to 0 when respondents choose neither alternative [68]. In CE, the ASC is specified to account for the proportion of WTP for an air quality improvement project in Klang Valley. A negative and significant ASC indicates a higher propensity to choose to pay for improved air quality in Klang Valley.

In simple SCLM, the number of sick days (NSD), medical expenditure (ME), air pollution index (API), and fuel price increase (BID) were considered the independent variables and utility of the respondents was considered the dependent variable. Therefore, the SCLM is as follows:

$$V_{ij} = ASC + \beta_1 NSD_{ij} + \beta_2 ME_{ij} + \beta_3 API_{ij} + \beta_4 BID_{ij} + \varepsilon \quad (11)$$

The estimated coefficients, t-value, and p- value for SCLM are summarised in Table 4. The McFadden's R^2 value in SCLM is similar to the R^2 in the conventional analysis except that significance occurs at lower levels. According to Hensher, the values of R^2 between 0.2 and 0.4 are considered to be extremely good fits [69]. Following this criterion, the overall fit of the SCLM (0.16) indicates a good fit and all the coefficients are statistically significant.

NSD (p-value = 0.000), ME (p-value = 0.000), API (p-value = 0.000), and BID (p-value = 0.091) were significant variables in the choice of options for air quality improvement in Klang Valley, ceteris paribus. The coefficient of the attributes represents the average WTP of each attribute for the air quality improvement options. These attributes increase the probability that the respondent would choose the air quality improvement option. In other words, the respondents give a value to those improved options that result in higher air quality. For example, the mean WTP of the respondents is between RM 0.23- RM 0.31 for the given attributes in the SCLM.

To gain insight into the sources of heterogeneity and to identify the social, economic, and demographic characteristics that may provide its foundations, a conditional logit interaction model (CLIM) with interaction was estimated using the following formula:

$$V_{ij} = ASC + \beta_1 NSD_{ij} + \beta_2 ME_{ij} + \beta_3 API_{ij} + \beta_4 BID_{ij} + BID^* EDU + BID^* HIC + BID^* CITY + BID^* AGE + BID^* ETH + BID^* OA + BID^* RS + \varepsilon \quad (12)$$

Table 4 presents the results of the CLIM with interaction variables for air quality improvement in Klang Valley. In this CLIM, the variables which are significant in CVM are selected to interact with the monetary attribute which is BID (RM/Litre). Since in CVM, education (EDU), household income (HIC), city, age, ethnicity (ETH), outdoor activities (OA), and respiratory symptoms (RS) were found to be significant and interacted with BID (RM/litre) in the CLIM. These interactions show how education, income, city, age, ethnicity, outdoor activities and respiratory symptoms modify the effect of BID on the probability of choice. The coefficients of the attributes, NSD, ME, and API were significant and had the expected positive signs at the 1% level. The coefficient of BID (RM/litre) was negative and significant at 10% of significance which supports the theory.

Table 4. Results from the simple conditional logit model & Conditional Logit Interaction Model (CLM)

	(SCLM)		(CLIM)	
Variable	Coefficient	S.E	Coefficient	S.E
Number of sick days	0.234	0.005	0.235	0.044
Medical expenditure	0.287	0.052	0.295	0.052
Air pollution index	0.312	0.043	0.323	0.053
Bid_EDU			0.411	0.413
Bid_HIC			0.056	0.095
Bid_CITY			-0.164	0.075
Bid_AGE			-0.023	0.006
Bid_ETH			-0.723	0.180
Bid_OA			0.417	0.102
Bid_RS			0.835	0.164
Bid	-1.824	1.078	-2.068	- 1.106
ASC_OPTION2	-1.049	-0.181	0.874	0.087 1
Summary Statistics No. of observations LogLikelihood(L(B)) Mcfadden-R^2	 1200 -1199.852 0.161		 1200 1158.049 0.171	

Note: The dependent variable is respondent's utility *(1 = choice of option, 0 = non choice),* ASC = alternative specific constant for option 1& 2, NSD = number of Sick Days, ME = Medical Expenditure, API = Air Pollution Index, BID = Extra payment for fuel price (RM/liter), EDU = Education, HIC = Household income, CITY = city, Age = Age, ETH =Ethnicity, OA = Outdoor Activities, RS = Respiratory Symptoms

The coefficient of education interacted with extra payment for fuel price is positive and significant. The odds of choosing options 1 or 2 increases by 50% for the highly educated relative to the less educated, ceteris paribus, although the BID level increased.

The coefficient of income interacted with extra payment for fuel price is also positive and significant. The odds of choosing options 1 or 2 increases 5% for those with higher incomes relative to the low-income group, although the BID level increased. (12)

The coefficient of city interacted with extra payment for fuel price was negative and significant (*p-value* = 0.0003). The odds of choosing options 1 or 2 decreases by 15% for the respondents living in a highly polluted area relative to the respondents living in a low or medium polluted area if the BID level is increased. This result is inconsistent with the theory[1].

The negative coefficient of age interacted with extra payment for fuel price is significant at 1% level of significance. This indicates that the odds of choosing options 1 or 2 decrease by 3% for the elderly relative to the youth, ceteris paribus if the BID is level increased. The coefficient of ethnicity interacted with extra payment for fuel price is also negative and significant at 1% level of significance. This result indicates that the odds of choosing options 1 or 2 decrease by 51% for Malays relative to the non-Malays if the BID level is increased.

The positive coefficient of outdoor activities interacted with extra payment for fuel price is positive and significant at 1% level of significance. The odds of choosing options 1 or 2 increases by 51% for those involved in more outdoor activities relative to those with few outdoor activities, ceteris paribus, if the BID level is increased. As expected, the positive coefficients of respiratory symptoms interacted with extra payment for fuel price are positive and significant at 1% level of significance. This indicates that ceteris paribus, the odds of choosing options 1 or 2 increases by 130% for the respondents with more respiratory symptoms relative to those with less respiratory symptoms if the BID level is increased.

The coefficient on ASC is negative and significant, implying that there is a degree of status quo bias, ceteris paribus, respondents would prefer to move away from the status quo situation [84] and towards improved air quality improvement programmes even if they have to pay extra for fuel price. Finally, the sign of the BID coefficient indicates that the effect on the utility of choosing a choice set with a higher bid level is negative, as expected.

The McFadden's R^2 value in conditional logit interaction model is 0.17 which is more than the R^2 value

[1] Note: Option 1 is an improved option due to air quality improvement, in which sick days is reduced from 5 days per month to 4 days per month, medical expenditure is reduced from RM 50 to RM 40, and Air Pollution Index is changed from unhealthy air day to moderate air day.

Option 2 is an improved option due to air quality improvement, in which sick days is reduced from 5 days per month to 3 days per month, medical expenditure is reduced from RM 50 to RM 30, and Air Pollution Index is changed from unhealthy air day to good air day.

in CLIM. This CLIM shows a better result. Besides the main attributes, age, ethnicity, outdoor activities, and respiratory symptoms are significant and have the expected sign as they are in CVM. Both simple logit model and condition logit interaction model are significant at the 1% level as shown by the chi-square statistic. The larger the value of the Log likelihood, the better the fit of the model to the observed data [85]. The McFadden- R^2 also allows us to compare the fit of different models.

The larger the value of the McFadden -R^2, the better the fit of the model to the observed data [86]. As shown in Table 4, both models have a larger value of the Log-likelihood and a larger pseudo-R^2, which is very close to the 20% level suggested by Louviere et al. as indicating a very good fit in this kind of data [68]. Furthermore, the CLIM has higher McFadden-R2 (0.17) compared to the SCLM (0.16). Therefore, CLIM with covariates is the superior model, and the marginal WTP are estimated from CLIM. The WTP for conditional logit model is presented as the marginal value of the attributes. The marginal WTP for each attributes using CLIM are shown in Table 5.

Table 5 Marginal WTP from Conditional Logit Interacted Model (CLIM)

Variable	CLIM	95% CI
Number of Sick days (NSD)	0.026	0.01-0.03
Medical Expenditure (ME)	0.032	0.04-0.05
Air Pollution Index (API)	0.061	0.05-0.08

Note: 95% confidential intervals (CI) are obtained by the delta method (Greene, 2000).

4.4. Comparison of the WTP Obtained from CVM and CE

In this study, the two different environmental valuation methods used are CVM and CE. Comparison of WTP is possible because CVM and CE share a common theoretical base, as previously discussed. In CVM, only one change has been considered where the suggested improvement is a reduction in NSD, ME, and improvement in API while the CE allows estimation of WTP impacts at different levels of the attributes. Thus, if WTP from each method is to be compared, CE should be restricted to estimate the WTP impact of the same improvement offered in CVM. For the CE, the change of alternative air quality improvement plan was valued using equation (10).

For CVM, WTP of the respondents is obtained from covariates. For the estimation of WTP, all the respondents willing to and not willing to pay were included in the logit model. Thus, the respondents' WTP is on average 23 cents extra payment for fuel price (RM/litre) in CVM. Since the current price of fuel is RM 1.90, the mean WTP of the respondents is RM 2.13 per litre of fuel for CVM. The mean WTP derived from both CVM and CE for the new alternative air quality improvement plan is presented in Table 6.

Table 6 reports that the mean WTP derived from CVM using the logit model is about RM 2.13 per litre. The mean WTP for the new air quality management programme derived from CE using CLIM is about RM 1.99 per litre. Here, the delta method was used to conduct the confidence interval to investigate whether the WTP obtained from CVM and CE is statistically different or not. The results show that the mean WTP derived from CVM is different from mean WTP derived from CE but not statistically different. This finding is in line with the studies; [40], [31], [32], [42], [50], [44], [45], [46].

Table 6 Mean WTP per Household Measures Based on CVM and CE

Methods	WTP (RM)	Extra WTP	95% CI (RM)
CVM	2.13	0.23	1.50-4.21
CE	1.99	0.09	0.80-3.10

Note: 95% confidential intervals (CI) are obtained by the delta method (Greene, 2000).

5. Conclusion and Recommendations

CVM and CE were performed to estimate the WTP and to identify the impact of a number of factors on the likelihood of the willingness of the respondents to pay a higher fuel price to improve the air quality in Klang Valley. There is a significant difference in the WTP obtained from CVM and CE though they are not statistically different. The study also shows that the CE method has some promising advantages over CVM. CE could provide the chance to extract a deeper understanding of selected attributes that would help to attain proficient air quality improvement options. It could be concluded from this study that the residents of Klang Valley have a positive WTP for the new air quality management programmes. This is a welcoming development towards a sustainable transportation system in Klang Valley. The high predictive power and statistical reliability of the models in both CVM and CE obtained in this study confirm that consistent results can be successfully obtained from both CVM and CE. Both CVM and CE are useful potential approaches for the future valuation of environmental goods in Klang Valley.

Since the respondents are willing to pay extra fuel price (MYR 0.09-0.23), the government could reduce the subsidy on the fuel price and utilise that money to improve and upgrade the public transportation towards a sustainable transport sectors. The money could be spent in fixing catalytic converter for the public vehicles, upgrading the infrastructure for the public transportation, increasing the number of green buses and trains, extending the public transport services to rural areas, and encouraging people to cycle. It is also possible to develop effeint and quitable moto vehicle rules and promote technolgy advancement in this area [86].

The findings of this study also reveal that a number of sick days, air pollution index, medical expenditure, outdoor activities, ethnic, city, age, and respiratory symptoms were significant variables that affected the WTP of the respondents in Klang Valley. In this aspect, the government by introducing initiatives to improve the air quality in Klang Valley, may reduce people's suffering from respiratory symptoms and associated medical expenditures. This will in turn encourage people to do more outdoor activities and live healthy.

Since mobile sources (transportation) are the biggest contributors of air pollutants, the increase of private vehicles and trips are emitting more harmful air pollutants [11]. To reverse the situation, the city planner and city council should take effective measures in managing and planning the city development. Smart growth or sustainable development shall be the first priority for tomorrow. A study in Midwestern United States shows that compact development patterns, when instituted over an ignescent period, can reduce vehicle travel and pollutant emissions in the metropolitan region [87].

The study also found that old people are willing to pay less than young people. The old people represents a large portion of society. The policy making for reducing air pollution cannot be effective if this section of population is ignored. Thus, it is necessary to educate old people that air pollution is a serious issue that leads to health problems. They can be encouraged to change their beliefs and lifestyles through campaigns, special functions, ceremonies, talks, training, workshops, field trips, and media buzz. In this way, they can be motivated to pay a higher fuel price for air quality improvement in Klang Valley. Furthermore, primary schools, colleges and universities can take part to reduce the environmental issues by introducing topics on environmental studies in their syllabus [88].

Acknowledgment

This research was funded by the Deanship of Scientific Research at Princess Nourah bint Abdulrahman University through the Fast-track Research Funding Program.

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